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Value Addition of Fruits: An Effective Process to Combat Post-harvest Losses

Shuvadeep Halder [a*], Boris Huirem [a], Sujata Karmakar [a], Abid Hayat [b] and Urjashi Bhattacharya [c]

[a] Department of Horticulture and Food Science, School of Agriculture and Allied Sciences, The Neotia University, Diamond Harbour, S 24 Pargana, 743368, India.
[b] Department of Horticulture, School of Agriculture, Seacom Skills University, Kendradangal, Birbhum, 731236, India.
[c] Department of Agronomy, School of Agriculture and Allied Sciences, The Neotia University, Diamond Harbour, S 24 Pargana, 743368, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Bruising, breaking, impact wounding, cutting, and other forms of injury are the common causes of deterioration and rotting losses of freshly harvested fruit crops due to poor harvesting, handling, storage, transportation, and marketing practices. For combating the huge losses, proper post-harvest management and value addition are considered an effective solution. Therefore, it is of utmost necessity to enlighten farm workers, producers, managers of trade, and exporters on the scope of losses being experienced and their financial drawbacks to improve the issue and enhance their income. This study aims to encompass different value-added food products like Ready to serve drinks, fruit bars, jam, jelly, marmalade, squash, pickles, candy, fruit powders, etc., that can be prepared easily from different fruits, especially the underutilized fruits when they are available in

**Corresponding author: E-mail: shuvadeep.halder@tnu.in;*

bulk during their harvesting season. This will reduce post-harvest losses and make them available for consumption in the off-season.

Keywords: Fruits; perishable; deterioration; value-addition.

1. INTRODUCTION

India ranks 2nd in fruit production throughout the world with a total production of 107.24 million metric tonnes in the year 2021-22 [1], just next to China. Despite having surplus production, huge losses are still prevalent due to their poor harvesting, handling, storage, transportation, and marketing practices. The losses of fruits and vegetables are a prime concern for India's agricultural sector [2] because such damaged produce fails to attract international buyers and brings the exporting country less profit and a bad name. This degradation in both quantity and quality of food production from harvest to consumption ultimately results in huge economic losses for the country.

Most fruits are highly perishable due to their tender texture and high moisture content. As a result, fresh fruits are very susceptible to mechanical injury such as bruising, breaking, impact wounding, cutting, and other forms of injury, which may cause a considerable (up to 40%) [3] amount of high-value nutritious product deterioration and rotting in a matter of a few hours or days. Lack of market demand, poor planning, and market information may also lead to overproduction of certain fruits that cannot be sold in time. This situation occurs most frequently in areas where transportation and storage facilities are inadequate [4].

Post-harvest losses of fruit crops significantly affect both the nutritional status of the population and the economy of the country. Fruits help keep human beings healthy as well as increase immunity by fulfilling their requirements for vitamins and minerals. Having enormous market potential for their nutritional security, fruits have a higher potential for value addition also, which gives high foreign exchange earnings and makes them an important item of trade. There are so many underutilized fruit crops such as aonla, karonda, bael, ber, passionfruit, jamun, jackfruit, tamarind, phalsa, wood apple, etc. that have great medicinal value and play a crucial role in reducing the problem of malnutrition [5]. However, their potentialities have been under-exploited and it is high time to focus on the underutilized fruit crops to ensure food, nutrition, and health security, as well as income generation of farmers and producers.

Considering the urgent need to solve the above problem to some extent, one strategic approach is to process the fruits into various value-added products that could be preserved for a long time. In this study, the recipes for the processing of various value-added underutilized fruits are provided briefly.

2. VALUE-ADDED PRODUCTS OF MANGOES

Though mango is the choicest fruit of the world but still selling fresh mango would be difficult owing to the market glut, poor transportation and improper cold storage facilities. But mango can be utilized in different stage of growth by preparing different value-added products.

During the early stages of growth mangoes are generally used for sweet or sour chutney. At stone hardening stage, they become suitable for products like amchur and pickle. Ripe mango have a characteristic blend of taste and flavor due to its good amount of sugar, pectin, carotenoids, etc. As because mangoes have comparatively shorter storage life, products should be made immediately after harvesting.

2.1 Mango Pickle

Green and fresh mangoes are chopped into pieces after being carefully cleaned with water. Then, the mustard oil is heated and spiced with various ingredients, like salt, turmeric, chili, and other spices. The oil is cooled and properly mixed with the mango slices. The spiced mangoes are dried in the sun for a few days in a large, flat container. With time, the mango slices soften imparting the flavor.

2.2 Mango Pulp

Mangoes are washed thoroughly with a 15ppm chlorine solution at 75°C and peeled. Pulping is carried out using a mesh size of 0.5 mm. Then, with the addition of sugar syrup, it is standardized between 15 and 18° Brix. To avoid discoloration, 0.1% ascorbic acid is added (Singh et al. 2020).

2.3 Mango RTS (Ready to Serve)

According to Rabbani and Singh [6], mango RTS and nectar can be made when they include 10% juice, 14% TSS, and 0.3% acidity. Delicious ready-to-serve (RTS) was also developed by Sakhale et al. [7] by combining soymilk and mango pulp in different ratios.

2.4 Mango Nectar

As stated by Rabbani and Singh [6], it can be made with 20% juice, 14% TSS, and 0.3% acidity. Tamburia Dasheri and Dasehri mangoes are preferable to Alphanso mangoes for producing canned mango nectar.

2.5 Mango Squash

Mango squash can be prepared and preserved in glass bottles using sulfur dioxide as a preservative at 350 ppm, 25% juice, maintaining 45% TSS, and 1.2-1.5% acidity [8].

2.6 Mango Toffee

Shakhale *et al*. [7] prepared toffee by combining Fig and mango pulp in an 80:20 ratio. They suggested that when making the toffee mixture, butter, and flavoring components should also be included. The cooked mass is sifted on a smooth surface to form a proper sheet that has already been lightly butter-dabbed. After adding the sugar, the pulp was boiled to one-third of its original volume, and the combination was heated to 65–70° Brix. Following the proper measurements, the sheet was cut to size and wrapped with butter paper (Singh *et al*., 2020).

2.7 Mango Jam

Shafaly *et al*. (2019) applied beal and reduced mango pulp in different ratios to make mango jam, and they concluded that pure mango pulp is best for jam preparation when compared to other mixed combinations. Six different mango varieties were used by Safder et al. [9]: Dusehri, Chaunsa, Langra, Anwar Ragtol, Malda, and Fajli. They discovered that Anwar Ragtol jam had the highest total sugar content and total soluble solids (68.28 °B). Singh *et al*. discovered that the Dusehri was superior in terms of organoleptic qualities in a similar experiment (Singh et al. 2020).

2.8 Mango Yogurt Drinks

Raut et al. [10] developed a mango yogurt drink blending mango pulp (6%) and yogurt. Three yogurt drinks with different ratios of mango pulp (97:3, 94:6, and 91:9) were made, along with a control yogurt drink, using 10% sugar and cold water.

2.9 Mango Lassi

Sagar and Khurdiya [11] prepare mango lassi by blending mango powder and curd in a 3:1 ratio.

2.10 Mango Ice-Cream

Mango powder and milk can be combined in the appropriate proportions to make ice cream. The ideal mixture for making ice cream, according to Birtnell [12], is milk and mango pulp powder in a 3:10 ratio.

2.11 Mango Chutney

It is a paste-like product that is made by cooking peeled, unripe mature mangos with various ingredients, such as spice, salt, vinegar, jaggery, onion, and garlic. It is hot, astringent, flavorful, and delightful. According to the FPO specification, chutney must have a minimum total soluble solids (TSS) content of 50^0B, 40% fruit pulp of the total final product, and 2.1% acidity. Sharma *et al*. [13] made chutney by blending bael and mango pulp in a variety of ratios. They demonstrated that the 40:60 ratio of bael and mango was the best of all possible combinations.

3. VALUE-ADDED PRODUCTS OF PAPAYA

Each and every part of papaya can be well utilized in making value added processed products. Unripe green fruit can be used for preparation of better quality candy as well as isolation of papain. So many value added products can be prepared from ripe fruits like RTS, squash, Jelly, jam and leather. Even seeds can be used to extract oil which has numerous health benefits.

3.1 Papaya Candy

Matured unripe papaya is taken and chopped into small and uniform pieces after removing the seeds. The pieces are washed and dried after cutting. It is then soaked for 30 minutes in cold water containing salt (2 g/100 ml) and calcium chloride (1 g/100 ml). Rinse with cold water after draining, then add sugar (approximately 1/4 the weight of the pieces) and boil for 5 minutes to enhance flavor and color. Heat for five minutes while adding a little extra sugar and citric acid (1 g/100 ml) after cooling and letting sit for four hours. Until the final Brix hits 70^0 Brix, the heating will continue [14].

3.2 Papaya Pickle

The seeds of mature green papayas are removed and diced after peeling and washing. It is then boiled in hot water, drained, and combined with salt, and seasoned. The final step is to pour the product into jars and add vinegar to the top of the product [14].

4. VALUE-ADDED PRODUCTS FROM MINOR AND UNDER UTILIZED FRUITS

Minor and under-utilized fruit crops are neglected and are not so extensively cultivated but very promising because of their enriched nutritional and medicinal value, and less requirement of care and management. About 150 minor consumable fruit tree sps are present in India but due to lack of popularity they remain underdeveloped and limited trade. There is always demand from consumers for new, delicious, nutritious and attractive food products.

4.1 Value-Added Products of Jackfruit

Jack fruit, one of the biggest fruits, is highly neglected food resources is almost a zero attention crop with high productivity. About 60-70% of Jack fruit grown are wasted yearly throughout the growing season in villages due to improper harvesting, inadequate storage facilities and lack of processing skills. Though there are very limited documentation on value addition of Jackfruit products but so many suitable varieties are available for processing.

4.2 Dehydrated Raw Jackfruit Flour

Jackfruit flour is a dehydrated product made from raw jackfruit bulbs. Due to its high fiber content and low glycemic index, this flour is becoming more and more popular as a substitute for rice and other cereal-based flour. This may be blended with so many traditional recipes to prepare various types of value-added products, including bakery goods, snacks, and breakfast cereal [15].

4.3 Jackfruit Candy

Jackfruit candy is made from fruit pulp that has been infused with cane sugar or glucose, drained, and dried [15]. Osmotic dehydration is the key component of jackfruit candy production. The jackfruit bulb that is just starting to ripen serves as the basis for jackfruit candy. The bulbs are first cleaned, submerged in a 65-70^0 B brix sugar solution, rinsed, and then mechanically dried at 60-62^0 C until completely dry.

4.4 Jackfruit Jam

To produce jackfruit jam, fruit pulp and sugar are cooked until they reach a thick consistency. The extracted pulp is cooked with sugar, acid, and pectin until 68.5° B is reached. Then jam is poured into sterilized, hot bottles and should be kept in a cold area [15].

4.5 Jackfruit Jelly

Jackfruit jelly is prepared from strained or clarified fruit extract. The clear extract is cooked in a solution of sugar and pectin to produce a clear, transparent, well-set jelly [15].

5. VALUE-ADDED PRODUCTS OF JAMUN

Good quality Jamun juice is used for syrup, sherbet, and squash Lai et al. [16]. Squash is made by cooking the smashed fruits for 5 to 10 minutes. It is then squeezed out and combined with sugar, water, citric acid, and sodium benzoate as a preservative. White-fleshed jamun has sufficient pectin and makes a moderately firm jelly [17].

6. VALUE-ADDED PRODUCTS OF BAEL

6.1 Bael Squash

A bael fruit squash should have 50% extracted pulp, 50% Brix, and 1% acidity and preserved by the addition of 300 ppm SO_2 [18]. Commercial fruit drinks must have at least 25% fruit pulp or juice, 40 –50% TSS, and 1% acid [19].

6.2 Bael Fruit Powder

According to Roy and Singh [18], bael fruit powder was made by drying the pulp to a thin sheet with moisture content below 4% before it is ground into powder.

7. VALUE-ADDED PRODUCTS OF WOOD APPLE

Fruit is eaten raw, although it must be sweetened due to its resinous flavor [20]. In 2013, Vijayakumar *et al.* [21]. studied the drying characteristics and quality evaluation of wood apple (*Feronia limonia* L.) fruit pulp powder. The pulp of the wood apple dries completely in 5 to 6 hours irrespective of the drying method. However, the sample dried in a hot air oven has a very rapid overall drying rate. The dehydration

ratio, rehydration ratio, and co-efficient of rehydration were all noticeably high in the tray-dried sample (p 0.01). The overall polyphenol content and antioxidant activity were much higher in sun-dried wood apple pulp powder.

8. VALUE-ADDED PRODUCTS OF AONLA

8.1 Aonla Jam

It should contain 45% fruit pulp and 68 % TSS. First, the fully ripe fruit is cleaned and peeled, and the pulp is extracted out. Following the addition of sugar and citric acid, the mixture is brought to a boil while being constantly stirred. The finished item is tested for a sheet test after heating it to a temperature of 105°C.

8.2 Aonla Sauce

10 g of salt, 75 g of sugar, 5 g of red peppers, 60 g of onion, 6 g of garlic, 12 g of ginger, and 12 g of hot spices were used to make five kg of sauce. To preserve the product, acetic acid and sodium benzoate were added at a rate of 1ml and 0.3g/kg, respectively. After processing it is filled into glass bottles and corked.

9. VALUE-ADDED PRODUCTS OF KARONDA

According to Chaudhary et al. [22], jelly can be prepared by karonda but the organoleptically acceptability lasts up to 4-5 months. Both the two types of karonda (Pink and green) can be used for pickle preparation which can be used for up to 4 months [23].

9.1 Value-Added Products of Ber

Several value-added products of ber can be prepared such as jam, candy, dehydrated ber, pickle, etc.

9.2 Ber Jam

It is prepared by heating the ber pulp with sugar by adding a small concentration of citric acid @0.2-0.3% [24]. Such finished ber jam with 0.3% citric acid could be stored for up to 60 days without quality deterioration.

9.3 Ber Candy

It can be prepared by first blanching and slow sugar syruping methods starting from syruping at 10^{o}Brix and the addition of 1% citric acid, keeping overnight and repeating the process till the 70^{o}Brix syrup is achieved followed by shade drying till desired moisture content of less than 18% is obtained [25].

9.4 Ber pickle

Pickling of ber can be prepared using acidulants such as lemon and vinegar along with salt and spices in different concentrations [26].

9.5 Ber Powder

It can be prepared with or without pretreating the ber samples such as blanching, osmotic, and sulfuring before drying in the open sun, different dryers, and dehydrators [27].

10. VALUE-ADDED PRODUCTS OF TAMARIND

Tamarind fruit can be used to prepare different value-added products such as chutney, candy, jam, Tamarind powder, pickles, etc.

10.1 Tamarind Chutney

Tamarind chutney can be prepared by cooking green immature fruits with spices and salt. This recipe is very common in South India.

10.2 Tamarind-Toffees and Candies

Tamarind-based candies can be prepared by boiling tamarind pulp with sugar and minimal water to achieve a natural sweet-sour taste which is then shaped into different sizes and shapes [28].

10.3 Tamarind Jam

Tamarind jam can be prepared by boiling the tamarind pulp with a sufficient amount of sugar [29].

10.4 Tamarind Puree/Paste

It can be prepared by removing seeds and fibrous material using a small amount of water with little heating. Such paste can be used for making tamarind rice, sambar with pulses, and other recipes.

10.5 Tamarind Pulp Powder

Tamarind powder can be prepared by dehydrating the tamarind pulp/puree and grinding it into powder. They produce an excellent tamarind-based drink by simply blending them with water. They are the richest source of tartaric acid [30].

10.6 Tamarind Pickle

Tamarind pickle can be prepared from matured and ripened fruit after removing the shells, fibers, and seeds which are then mixed with spices and

salt offering a spicy, sour, and sweet taste. The pickles thus prepared can be kept for more than a year.

11. VALUE-ADDED PRODUCTS OF PASSIONFRUIT

Some of the value-added products include fruit jam, jelly, juice, dried passionfruit, fruit wine, etc.

11.1 Passion Fruit Juice

Passion fruit pulp or juice is obtained directly from the fruit or squeezed from crushed material with a significant proportion of pulp by separating the seed from the pulp [31]. The juice thus prepared can be preserved for six months to a year with the help of preservatives.

11.2 Passionfruit Jam/Jelly

Fruit pulp and juice can be changed into jam and jelly using sufficient sugar and pectin as a setting agent.

11.3 Dried Passionfruit

The storage life of passion fruit can be extended by removing water after drying it with hot air until the moisture content of around 5% is achieved with or without pre-treatment depending on the desired quality parameters like flavor, color, and taste retention [32,33].

12. CONCLUSION

The perishable nature coupled with the lack of storage infrastructure has limited the shelf life of freshly harvested fruits leading to huge losses every year. This affected the farmers and producers to fetch little income despite having surplus production during the harvesting season. Therefore, one of the strategic solutions to this problem is the processing of different value-added products as much as possible. This will help the farmers to double their income and at the same time enhance the economy of our country to some extent.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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